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IMPACT AND INCIDENCE OF FUSIFORM RUST ON SLASH PINE
PLANTATIONS IN CENTRAL LOUISIANA

A Progress Report

U. S. FOREST SERVICE
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by

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ABSTRACT

Theoretical thinnings, which removed only stem-cankered trees, reduced the volume present in four slash pine (Pinus elliottii Engelm. var. elliottii) stands planted in 1964 by 12.2 to 25.5 percent. Volume was reduced on three 1959 plantations by 22.3 to 31.5 percent. Basal area per acre on the 1959 plantations was reduced to 92, 67, and 71 square feet. Only the last two might be considered heavily thinned. Increases in rust mortality between 1975 and 1976 occurred in stands planted in 1973, 1972, 1971, 1969, 1964, and 1959. Stem-cankered trees increased on 1964, 1969, 1971, and 1972 plantations. Branch cankers increased in 1973, 1964, and 1959 plantations. Decreases occurred in the 1969, 1972, and 1971 plantations with the latter age class showing a large decrease in branch cankers. Mortality from causes other than fusiform rust increased on the 1971, 1972, and 1973 plantings. Stems rendered nonmerchantable (cabbages) by rust, though uncommon, were most prevalent in the 1969, 1971, and 1972 plantings. Seedlings dying from causes other than rust were most prevalent in the 1973 plantings. Rust mortality occurred most often and healthy trees least often in the 1964 plantings. Branch cankers were greatest in the 1971 stands. Stem-cankered trees were most prevalent in the 1972 plantings. Branch cankers which grew into the stem were most common in the 1971 plantings.

INTRODUCTION

In 1974, 24 slash pine, *Pinus elliottii* Engelm. var. *elliottii*, plantations in Central Louisiana -- six age classes with four plantations in each class -- were sampled for fusiform rust (*Cronartium fusiforme* Hedg. and Hunt) infection. Six rows with approximately 100 trees in each row were sampled per

plantation. The plantations were 1, 2, 3, 5, 10, and 15 years old. A second reading in 1975 was taken on these plantations. In addition, four stands planted in 1974 were read in 1975 to keep abreast of current rust incidence. Each year all stands are read between January and March. Between the two readings, increases in rust mortality occurred in the 1, 2, 5, and 10-year classes (Affeltranger, 1975). Stem cankers increased in the 2- and 3-year classes. Mortality from causes other than rust increased in the 2-, 3-, and 5-year classes, while a very large increase occurred with the 1-year age class. Nursery infections (8.7 percent) exceeded field infections (7.5 percent) in the 1974 plantings.

Readings for this evaluation (1976) were made on those original plantations sampled in 1974 and 1975 and on first year 1975 plantations.

An objective of the study is to determine volume impact and residual basal area following theoretical thinnings on the plantations established in 1959 and 1964. Stocking will be the measure of impact for the younger plantations.

IMPACT OF FUSIFORM RUST

MATERIALS AND METHODS

Impact was measured by volume removed in stands planted in 1964 and by volume removed and residual basal area in 1959 plantations. A tree to be selected for thinning had to meet three criteria (Lindgren, 1948):

- 1) Measure at least 4.5" in diameter breast height;
- 2) Possess a stem canker at a height of 16' or less;
- 3) Possess a canker, or cankers, which girdled the stem 50 percent or more.

Volume per tree in cords from Minor's form class volume tables was determined by diameter, height, and form class measurements. Three heights were taken with a clinometer for each diameter class in each plantation. Diameters were taken with stem calipers. Diameters associated with form class were obtained with a diameter tape and bark gauge.

RESULTS

1959 Plantations

Three plantations were theoretically thinned in January 1976. Volume loss varied from 22.3 to 31.5 percent. One of the plantations had three of its six sample rows thinned by Crown-Zellerbach in February 1975, so data were taken on only these three rows. The percentages of volume lost are based on the three to six row samples rather than on an acre. Results on volume removed and residual basal area per acre are presented in Table 1.

Table 1. Percentage of volume removed and residual basal area per acre (B.A./A) from theoretical thinnings made on three 1959 fusiform rust infected slash pine plantations in central Louisiana in 1976.

Plantation Number	Percentage of ⁺ Volume removed	B.A./A before thinning	B.A./A removed	Residual BA./A
1*	22.3	119.2 ft. ²	27.0 ft. ²	92.2 ft. ²
2	31.5	96.0	29.4	66.6
3	28.0	99.5	28.3	71.2

+ Includes trees which reached merchantable diameters, but died of rust or were rendered nonmerchantable by rust ("cabbages").

* Only three rows of usual six-row sample were theoretically thinned.

1964 Plantations

Theoretical thinnings were made on 1964 plantings in December 1975 and January 1976. Residual basal area was not used as a measure of impact because a basal area per acre figure could not be decided upon for these young plantations. Table 2 summarizes the volume impact for these plantations.

Table 2. Volume impact expressed as a percent for four 1964 fusiform rust infected slash pine plantations theoretically thinned (December 1975 and January 1976) in central Louisiana.

Plantation Number	Percentage of Volume Removed
1	23.2
2	25.5
3	13.7
4	12.2

INCIDENCE OF FUSIFORM RUST

METHODS

The respective categories for these condition classes are:

1. Healthy
2. Stem canker
3. Branch canker
4. Dead-rust
5. Nonmerchantable or "cabbage"
6. Dead-other

1959 Plantations

Increases, as compared to 1975, in this age class occurred in the dead-rust and branch canker categories, while the stem-canker, dead-other, and nonmerchantable categories did not increase.

Table 3. Percentage of trees in the respective condition classes and percentage of trees in condition classes 2, 4, 5, for three 1959 fusiform rust infected slash pine plantations in central Louisiana in 1974, 1975, and 1976 (s = standard deviation).

Plantation Number	Condition Class						2, 4, 5
	1	2	3	4	5	6	
1*	30.0	41.0	15.0	13.0	0.0	1.0	54.0
2	34.4	41.0	14.6	8.4	0.2	1.5	49.5
3	25.0	45.1	18.0	11.6	0.0	0.3	56.7
Average±s	29.8±4.7	42.6±2.4	16.0±1.9	10.6±2.4	0.1±0.1	0.9±0.6	53.3±3.6
1975 Avg.	38.0	39.9	13.9	7.6	0.1	0.5	47.6
1974 Avg.	51.6	35.6	5.6	6.9	0.0	0.2	42.6

* Data for three rows only

1964 Plantations

Increases were realized in the branch canker, stem canker, and dead-rust categories. This age class revealed the fewest healthy and the most dead-rust of any age class (Table 4).

Table 4. Percentage of trees in the respective condition classes and percentage of trees in condition classes 2, 4, 5, for four 1964 fusiform rust infested slash pine plantations in central Louisiana in 1976.

Plantation Number	Condition Class						2, 4, 5
	1	2	3	4	5	6	
1	19.1	40.6	18.1	21.0	0.2	1.1	61.7
2	19.5	41.2	15.9	21.4	1.3	0.7	63.9
3	32.0	36.0	24.2	7.2	0.2	0.5	43.3
4	32.3	35.1	24.4	6.7	1.2	0.3	43.0
Average±s	25.7±7.4	38.2±3.1	20.6±4.3	14.1±8.2	0.7±0.6	0.7±0.3	53.0±11.4
1975 Avg	35.4	31.9	19.0	12.3	0.6	0.7	44.9
1974 Avg	51.4	32.1	6.8	8.2	1.2	0.5	41.4

1969 Plantations

Increases over 1975 data occurred in the stem canker and dead-rust categories (Table 5). Decreases were found in the branch canker and nonmerchantable categories. The dead-other category remained about the same. Plantations of this age group revealed the most nonmerchantable stems (Table 5).

Table 5. Percentage of trees in the respective condition classes and percentage of trees in condition classes 2, 4, 5, for four 1969 fusiform rust infected slash pine plantations in central Louisiana in 1976.

Plantation Number	Condition Class						
	1	2	3	4	5	6	2, 4, 5
1	35.2	23.0	25.0	10.7	0.0	6.1	33.7
2	24.0	35.1	20.2	14.9	2.3	3.5	52.3
3	22.0	44.7	18.7	12.0	2.0	0.7	58.7
4	24.6	55.7	13.4	4.3	1.7	0.3	61.7
Average±s	26.5±5.9	39.6±13.9	19.3±4.8	10.5±4.5	1.5±1.0	2.7±2.7	51.5±12.6
1975 Avg.	30.2	29.3	26.3	8.5	2.4	3.2	40.2
1974 Avg.	49.3	32.0	12.0	3.6	2.9	0.3	38.4

1971 Plantation

This age class showed increases in the two mortality categories and stem cankers (Table 6). There was a large decrease in branch cankers mainly because these either died or grew into the stem. These plantations still have the most branch cankers and also had the most branch cankers growing into the stem (Table 6).

Table 6. Percentage of trees in the respective condition classes and percentage of trees in condition classes 2, 4, 5, for four 1971 slash pine plantations in central Louisiana in 1976.

Plantation Number	Condition Class						
	1	2	3	4	5	6	2, 4, 5
1	42.4	22.3	14.0	8.5	0.2	12.6	30.9
2	44.9	23.1	25.4	2.8	0.3	3.5	26.2
3	21.7	44.8	26.3	2.2	2.8	2.2	49.8
4	41.2	19.8	31.5	2.2	0.2	5.2	22.2
Average±s	37.6±10.7	27.5±11.6	24.3±7.4	3.9±3.1	0.9±1.3	5.9±4.7	32.3±12.2
1975 Avg.	35.5	20.8	40.2	1.0	0.7	1.8	22.5
1974 Avg.	47.5	11.2	38.5	0.5	0.6	0.5	13.6

1972 Plantations

These young plantations revealed increases in the mortality categories, stem cankers and nonmerchantable stems. A decrease was realized in the branch canker category, mainly because many branch cankers grew into the stem. This class was second only to the 1971 plantations with respect to ingrowth of branch cankers. These plantations have more stem cankers and fewer dead-rust trees than any age class (Table 7).

Table 7. Percentage of trees in the respective condition classes and percentage of trees in condition classes 2, 4, 5 for four 1972 fusiform rust infected slash pine plantations in central Louisiana in 1976.

Plantation Number	Condition Class						
	1	2	3	4	5	6	2, 4, 5
1	40.5	46.5	7.4	0.3	2.3	3.0	49.2
2	37.1	38.9	14.9	4.0	0.2	5.0	43.1
3	24.2	45.3	21.7	2.7	1.8	4.2	49.8
4	24.9	47.4	17.4	5.0	0.3	5.0	52.7
Average±s	31.7±8.4	44.5±3.8	15.3±6.0	3.0±2.0	1.2±1.1	4.3±1.0	48.7±4.0
1975 Avg.	38.8	38.2	17.6	1.3	0.7	3.5	40.1
1974 Avg.	51.7	29.6	17.1	0.2	0.5	0.8	30.4

1973 Plantations

These young stands showed another large increase in the dead-other category for which this age class leads (Table 8). Mortality from all causes reached 30 to 33 percent on two of these plantations. However, there were also large increases in the dead-rust and branch canker categories, while stem cankers and nonmerchantable stems remained constant. As would be expected, this age class had more healthy trees than any other age class (Table 8).

Table 8. Percentage of trees in the respective condition classes and percentage of trees in condition classes 2, 4, 5 for four 1973 fusiform rust infected slash pine plantations in central Louisiana in 1976.

Plantation Number	Condition Class						
	1	2	3	4	5	6	2, 4, 5
1	41.8	36.7	6.5	8.2	0.0	6.8	44.8
2	36.6	26.5	3.3	13.3	0.3	20.0	40.1
3	45.1	18.6	5.8	8.3	0.2	22.0	27.1
4	45.3	35.8	3.8	8.8	0.3	5.8	45.0
Average±s	42.2±4.1	29.4±8.6	4.9±1.5	9.7±2.4	0.2±0.1	13.7±8.5	39.3±8.4
1975 Avg.	53.2	29.6	1.4	5.5	0.1	10.2	35.2
1974 Avg.	64.6	30.5	2.0	1.5	0.1	1.3	32.1

Total infection for 1973 and older plantations was 62.6 percent. The percentage of trees on these plantations in condition classes 2, 4, and 5, which indicate those trees having a stem canker at some time during their lives, was 45.7.

Condition class following thinning was taken on a fourth 1959 plantation. Out of 217 trees cut, 77 (35.5 percent) had stem cankers. Thinning on three rows of another 1959 plantation revealed that out of 77 trees cut, 62 (80.5 percent) had stem cankers.

A check was also kept on current infection by looking at four 1975 plantations. These revealed very little infection and observations indicated that the seedlings were suffering more from mechanical damage or poor planting methods than from rust. Nursery infection incidence was much lower than it had been in the 1974 plantations checked in 1975. Table 9 gives the condition class data for these new plantations.

Table 9. Percentage of seedlings in the respective condition classes for four 1975 fusiform rust infected slash pine plantations in central Louisiana in 1976.

Plantation Number	Condition Class					
	1	2	3	4	5	6
1	95.3	2.0	0.7	0.0	0.0	2.0
2	87.8	6.7	1.8	0.2	0.0	3.5
3	85.3	7.2	2.7	0.0	0.2	4.7
4	91.7	2.2	0.8	0.0	0.0	5.3
Average±s	90.0±4.4	4.5±2.8	1.5±0.9	0.0±0.1	0.0±0.1	3.9±1.5

DISCUSSION

These slash pine plantations are highly infected (62.6 percent). Dinus (1974) attempted to explain why fusiform rust is so troublesome in the South. He pointed out that prescribed burning used in slash and loblolly, *P. taeda* L. plantations is favorable to the sprouting of the alternate host, and consequently, increases inoculum levels. Land clearing released susceptible oaks and favored their establishment. Slash pine is now being grown on sites formerly occupied by longleaf pine, *P. palustris* Mill. This is the situation in central Louisiana. Whereas longleaf is less susceptible to rust than loblolly pine, slash pine is probably the most susceptible pine to the disease. Nursery seedlings used in the establishment of slash pine plantations were often highly infected. A small percentage of those that were infected survived for five or more years, thus spreading and intensifying rust infection. Before this alteration of the forest

environment, reports indicated that fusiform rust was rare prior to 1900. Now the range of the disease is in the form of a large corridor which closely follows the natural range of longleaf pine.

The data from this study corroborates the theories of Dinus. Not only is 62.6 percent a high rate of total infection, but 45.7 percent of all trees (excluding 1974 and 1975 plantations) had stem cankers at one time. These trees are then lethally infected. Residual basal areas on two 1959 plantations, subjected to theoretical thinnings, amounted to approximately 70 square feet, which may have left these stands understocked. Many foresters in the South consider 80 - 85 square feet to be adequate. Enghardt and Mann (1972) found that volume growth between ages 17 and 22 increased with a higher residual basal area per acre at age 17. Reductions in volume from the theoretical thinnings were higher on the 1959 plantations than the 1964 plantations indicating that more volume may be lost to rust in the future on the 1964 plantings.

Even more serious may be the high rate of total and potentially lethal infections found on the younger plantations. Over 50 percent of the trees on the 1969 plantings have potentially lethal infections. Nearly fifty percent of the 1972 trees are potentially lethally infected. Plantings made in 1971 and 1973 are 30 to 40 percent infected in this regard. Will enough trees survive on these plantations to make harvest profitable? Two factors which make this situation worse is the use of the plow lines and prescribed burning, which reduce fire hazard, but add to mortality, which is already high. It might be best to forego these two practices where high rust infection is present.

Theoretical thinnings will again be conducted on the 1959 and 1964 plantations in 1978. This evaluation will be terminated in 1978.

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